GeMini Plus: A Miniature Gamma Ray Spectrometer to Measure Near-surface Elemental Composition and Stratigraphy for Resource-Limited Planetary Missions

Completed Technology Project (2015 - 2017)

Project Introduction

Knowing the elemental composition of a planetary surface is key to understanding its formation and evolution. Planetary gamma-ray spectroscopy is a well-established technique for remotely measuring planetary elemental concentrations. It is unique among the available techniques in that it measures bulk concentrations to depths of tens of cm (in contrast to techniques sensitive only to the top tens of microns) and can quantify compositional stratigraphy within this depth range. Orbital gamma-ray measurements have resulted in significant discoveries from the Moon, Mars, Mercury, and asteroids. Gamma-ray spectroscopy can provide foundational science results for future missions such as landers, rovers and orbital reconnaissance missions at a wide variety of planetary bodies. However, many of these missions will be resource limited; present gamma-ray instruments have relatively large mass and power requirements that will limit their use to missions with large available resources. 'GeMini Plus' is a new type of gamma-ray spectrometer that brings the power of high-resolution germanium to missions with low resources (2.5 kg, 5.5 W). Gemini Plus uses a cryogenically cooled, high-purity Ge (HPGe) sensor to measure gamma rays with an energy resolution and precision that is unmatched by any other technology. This new instrument represents a significant reduction in resources compared to equivalent heritage instruments (>10 kg, >16 W) and opens the possibility for new science objectives not previously available to resource-limited missions such as small, landed packages. Although HPGe sensors have been successful on previous missions, a remaining challenge is preserving their pre-launch performance throughout long-duration missions. In particular, HPGe sensors are susceptible to radiation damage, which degrades their energy resolution performance after long exposures to galactic and solar energetic charged particles. While some operation scenarios limit radiation exposure, for example short cruises (<1 year) and operation in lower-radiation environments (e.g. Mars' surface where its atmosphere reduces solar charged particle radiation), many mission scenarios (e.g., asteroid belt destinations, Trojan asteroids) have long and unavoidable cruises. Additionally, the adoption of solar-electric propulsion further lengthens interplanetary cruise lengths. To address this challenge, we propose a detailed technology maturation program where we will develop and test hardware and signal processing techniques that mitigate radiation damage in HPGe sensors, preserving laboratory quality measurement capabilities for the target of interest. This work will be accomplished in two main areas. First, we will procure custom HPGe detectors, irradiate them with energetic ions to simulate the relevant environment of long-duration space exposure (>3+ years), and test hardware-based damage mitigation procedures (e.g., repeated high-temperature annealing). Second, we will develop and test digital signal processing algorithms that have been shown to accurately correct signals affected by radiation damage and thus recover energy resolution electronically. Ultimately, these new capabilities will be integrated into a GeMini Plus instrument and fully tested in space-relevant

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Organizational Responsibility

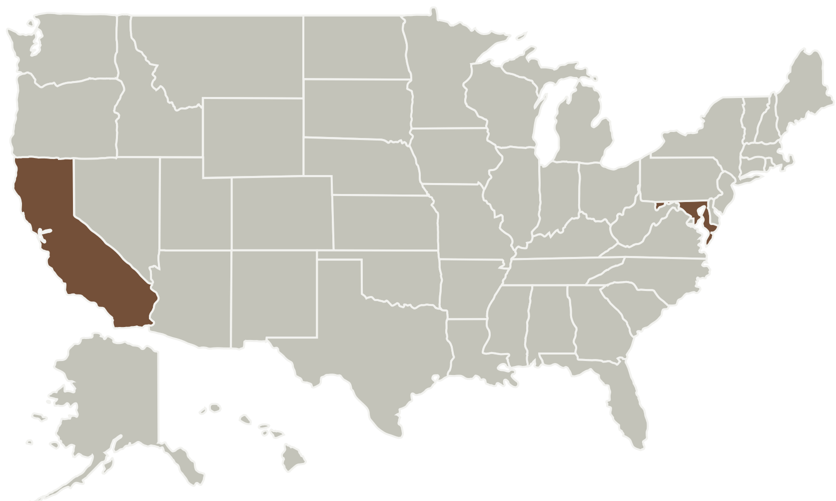
Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

Maturation of Instruments for Solar System Exploration environments (radiation, thermal, vacuum) to validate this technology as TRL6. At the completion of this MatISSE development, the combination of high-value science return, low instrument resources, and simple operation will make GeMini Plus a 'first choice' instrument for any mission that requires elemental compositional measurements of a planetary surface.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Johns Hopkins University	Supporting Organization	Academia	Baltimore, Maryland
Johns Hopkins University Applied Physics Laboratory(JHU/APL)	Supporting Organization	R&D Center	Laurel, Maryland

Primary U.S. Work Locations	
California	Maryland

Project Management

Program Director:

Carolyn R Mercer

Program Manager:

Haris Riris

Principal Investigator:

David J Lawrence

Co-Investigators:

Patrick Peplowski
John Goldsten
Felicia Hastings
Morgan Burks

Technology Areas

Primary:

- TX07 Exploration Destination Systems
  └ TX07.1 In-Situ Resource Utilization
    └ TX07.1.1 Destination Reconnaissance and Resource Assessment

Target Destination

Others Inside the Solar System